I-17 CORRIDOR PROFILE STUDY

SR 101L TO I-40

ADOT Work Task No. MPD 072B-14

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Draft Working Paper 5: Strategic Solutions

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PREPARED FOR:

Arizona Department of Transportation

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1 INTRODUCTION

The Arizona Department of Transportation (ADOT) is the lead agency for this corridor profile study of Interstate 17 (I-17) between SR 101L in Phoenix and I-40 in Flagstaff. This study will look at key performance measures relative to the I-17 corridor, and use those as a means to prioritize future improvements in areas that show critical deficiencies. The intent of the corridor profile program, and of the Planning to Programming process, is to conduct performance-based planning to identify areas of need and make the most efficient use of available funding to provide an efficient transportation network.

1.1 Corridor Overview

The Arizona Sun Corridor is one of eleven megapolitan areas in the United States, defined as a conglomeration of two or more intertwined metropolitan areas. The Sun Corridor megapolitan extends from Nogales to Prescott, and is similar to Indiana in area and population. The Sun Corridor is one of the fastest growing areas in the country, with I-17 playing a key role in the transportation infrastructure of its northern portion, contributing to its economic success.

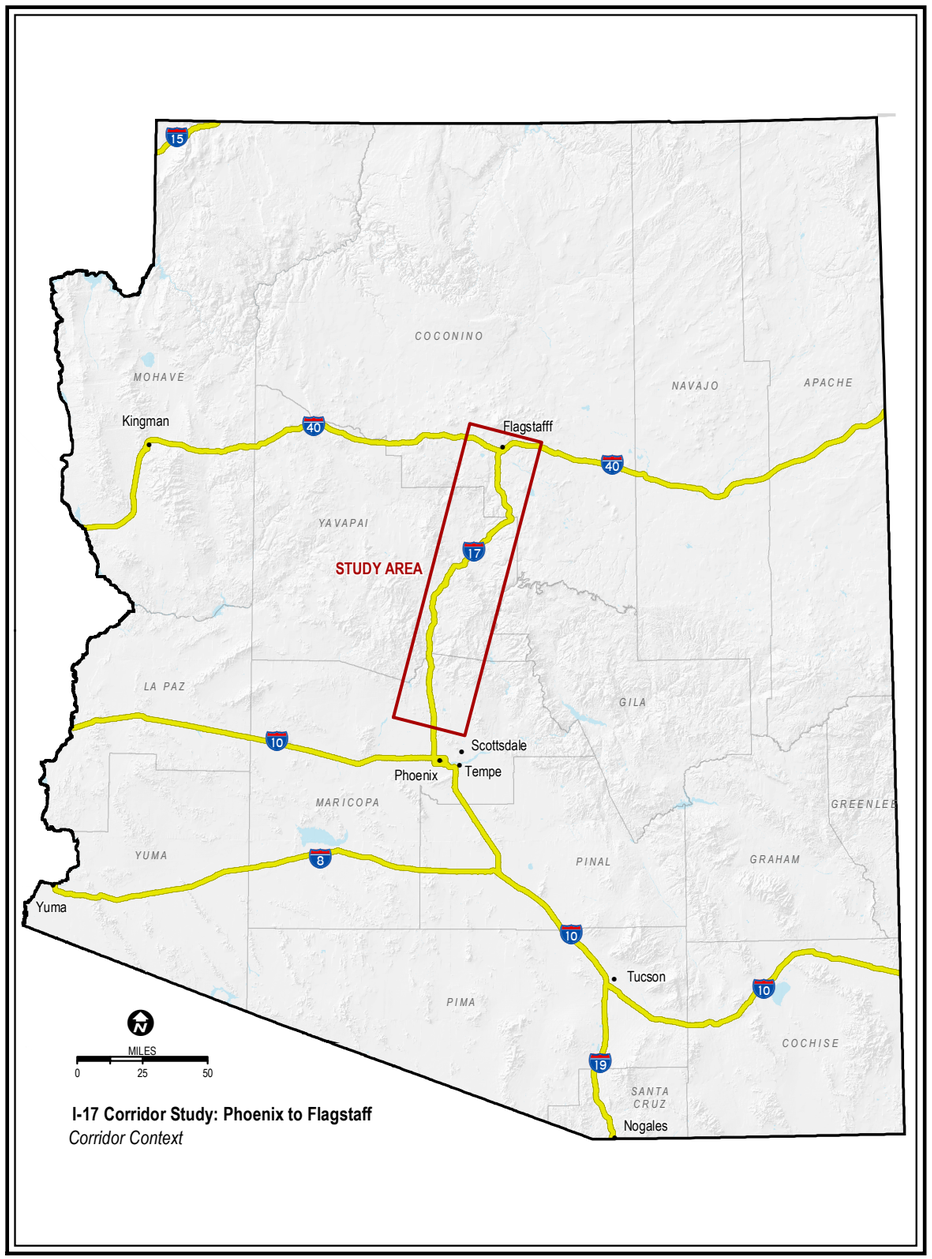
I-17 provides the most direct and fastest link between Phoenix (and I-10) and Flagstaff (and I-40) (**Figure 1**). I-17 provides a principal road link for national and international traffic from Phoenix Sky Harbor International Airport to Prescott, the Verde Valley, Sedona, Flagstaff, the Grand Canyon, and the Navajo and Hopi nations (**Figure 2**). This study builds on earlier planning efforts in developing and applying a performance-based process for prioritizing improvements to meet present and future needs in the corridor.

1.2 Corridor Study Purpose

ADOT seeks to identify a new corridor planning approach to develop strategies and tools that incorporate life-cycle cost analysis and risk assessment to measure system performance. This Corridor Profile Study, along with similar studies of I-19 and I-40, will develop a new process to:

- Inventory past improvement recommendations.
- Assess the existing performance based on quantifiable performance measures.
- Propose various solutions to improve corridor performance.
- Identify specific projects that can provide quantifiable benefits in relation to the performance measures.
- Recommend strategic projects for future consideration in the P2P programming process

Figure 1: Study Location Map



1.3 Corridor Study Objective

The objective of this study is to identify a recommended set of potential projects for consideration in future construction programs, derived from a transparent, defensible, logical, and replicable process.

1.4 Working Paper Objectives

The objective of Working Paper #5 is to document the identification of strategic solutions derived from a performance-based needs assessment for the I-17 corridor. Corridor needs (Working Paper #4) were defined through a review of the difference in baseline corridor performance (Working Paper #2) and the performance objectives (Working Paper #3) for each of the five performance areas used to characterize the health of the corridor: pavement, bridge, mobility, safety, and freight.

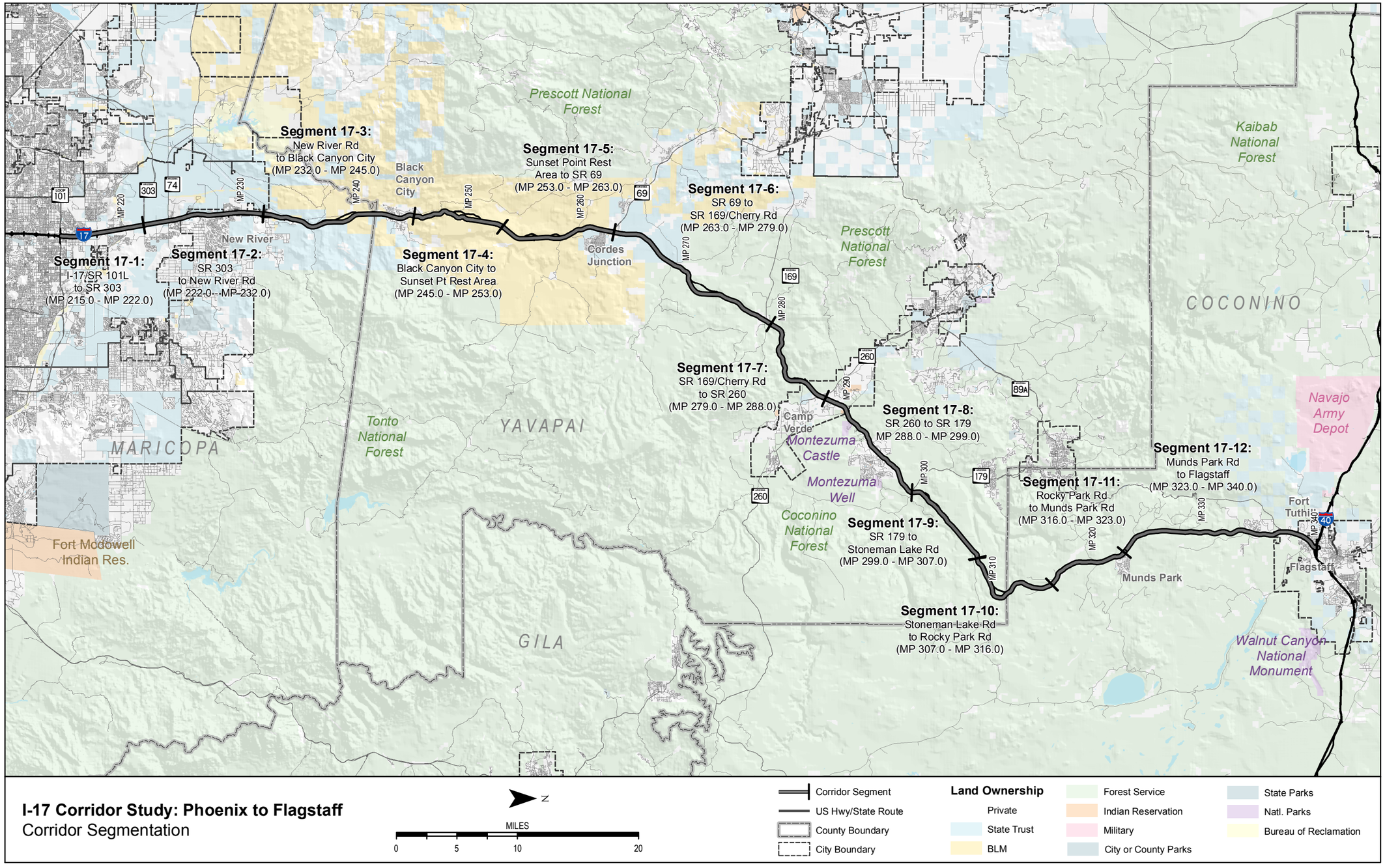
1.5 Study Location and Corridor Segments

The I-17 Corridor is 125 miles long, from SR 101L (Milepost [MP] 215.0) to I-40 (MP 340.0). The corridor has been divided into twelve distinct segments based on regionally significant intersecting routes, changes in topography, or natural or man-made landmarks along the corridor. The shortest segment is seven miles long and the longest, seventeen miles. Corridor Segments have been described in **Table 1** below, and shown on a map in **Figure 2**.

Table 1: Corridor Segmentation

Segment #	Segment Description	Character Description
Segment 1	SR101L to SR 303L (MP 215.0 to MP 222.0)	Segment 1 is generally urban/fringe-urban in nature while Segment 2 is generally rural in nature. Both are within the urbanized limits of the Phoenix Metropolitan Area in Maricopa County. Segment 1 includes six interchanges and Segment 2 includes six interchanges.
Segment 2	SR 303L to New River Road (MP 222.0 to MP 232.0)	
Segment 3	New River Road to Black Canyon City (MP 232.0 to MP 245.0)	Segment 3 is generally rural in nature, includes three interchanges, and spans both Maricopa and Yavapai Counties
Segment 4	Black Canyon City to Sunset Point Rest Area (MP 245.0 to MP 253.0)	Segment 4 is rural in nature, includes significant changes in topography, two interchanges, and is within Yavapai County.
Segment 5	Sunset Point Rest Area to SR 69 (MP 253.0 to MP 263.0)	Segment 5 is rural in nature, includes changes in topography, three interchanges, and is located within Yavapai County.
Segment 6	SR 69 to SR 169 (MP 263.0 to MP 279.0)	Segment 6 is rural in nature, passes through generally rolling terrain, includes two interchanges, and is located within Yavapai County.
Segment 7	SR 169 to SR 260 (MP 279.0 to MP 288.0)	Segment 7 goes through significant topography and elevation changes, is rural in nature, includes two interchanges, and is within Yavapai County.
Segment 8	SR 260 to SR 179 (MP 288.0 to MP 299.0)	Segment 8 passes through gradual elevation changes, is rural in character, includes three interchanges, and is located within Yavapai County.
Segment 9	SR 179 to Stoneman Lake Road (MP 299.0 to MP 307.0)	Segment 9 is rural in nature, includes changes in topography, one interchange, and is located within Yavapai County.
Segment 10	Stoneman Lake Road to Rocky Park Road (MP 307.0 to MP 316.0)	Segment 10 is rural in nature, includes changes in topography, one interchange, and spans both Yavapai and Coconino Counties.
Segment 11	Rocky Park Road to Munds Park Road (MP 316.0 to MP 323.0)	Segment 11 is rural in nature, includes three interchanges, and is located within Coconino County.
Segment 12	Munds Park Road to I-40 (MP 323.0 to MP 340.0)	Segment 12 transitions from a rural setting to a fringe-urban setting, includes four interchanges, is located within Coconino County, and extends into the City of Flagstaff.

Figure 2: Project Vicinity/Segmentation Map



2 SUMMARY OF CORRIDOR NEEDS

2.1 Summary of Needs

Working Paper #4 documented the framework for the performance-based needs assessment process and the results for the I-17 corridor. The needs in each performance area were classified as either None, Low, Medium, or High based on a comparison of the corridor performance (Working Paper #2) to the performance objectives (Working Paper #3). The needs for the I-17 corridor are summarized below.

Pavement Performance Area

- Pavement Needs were identified on 3 of the 12 segments which encompass 37 miles (30%) of the I-17 corridor with a majority being located at the north end of the corridor.
- A high level of historical investment has occurred on approximately 40 miles of the corridor (MP 285 to 312 and MP 327 to 340) which may warrant further investigation or alternative solutions.

Bridge Performance Area

- Bridge Needs were identified on 9 of the 12 segments which include 13 of the 99 bridges (13%) along the I-17 corridor.
- Five bridges have potential repetitive investment issues which may be candidates for life-cycle cost analysis to evaluate alternative solutions.

Mobility Performance Area

- The Mobility Performance Area is an Emphasis Area for the I-17 corridor. Mobility Needs were identified on 11 of the 12 segments which encompass 114 miles (90%) of the I-17 corridor.
- The highest levels of need have been identified in areas of mountainous terrain.
- The lowest trip reliability on corridor is along northbound I-17 between MP 245 and 253.

Safety Performance Area

- The Safety Performance Area is an Emphasis Area for the I-17 corridor. Safety Needs were identified on the entire I-17 corridor.
- The highest levels of need have been identified from MP 222 to 232, MP 263 to 279, and MP 288 to 307.

Freight Performance Area

- Freight Needs were identified on 11 of the 12 segments which encompass 115 miles (90%) of the I-17 corridor.
- The highest levels of need have been identified in areas of mountainous terrain.
- Two bridges provide less than 16’ vertical clearance and the ramp configurations do not allows trucks to by-pass the restriction.

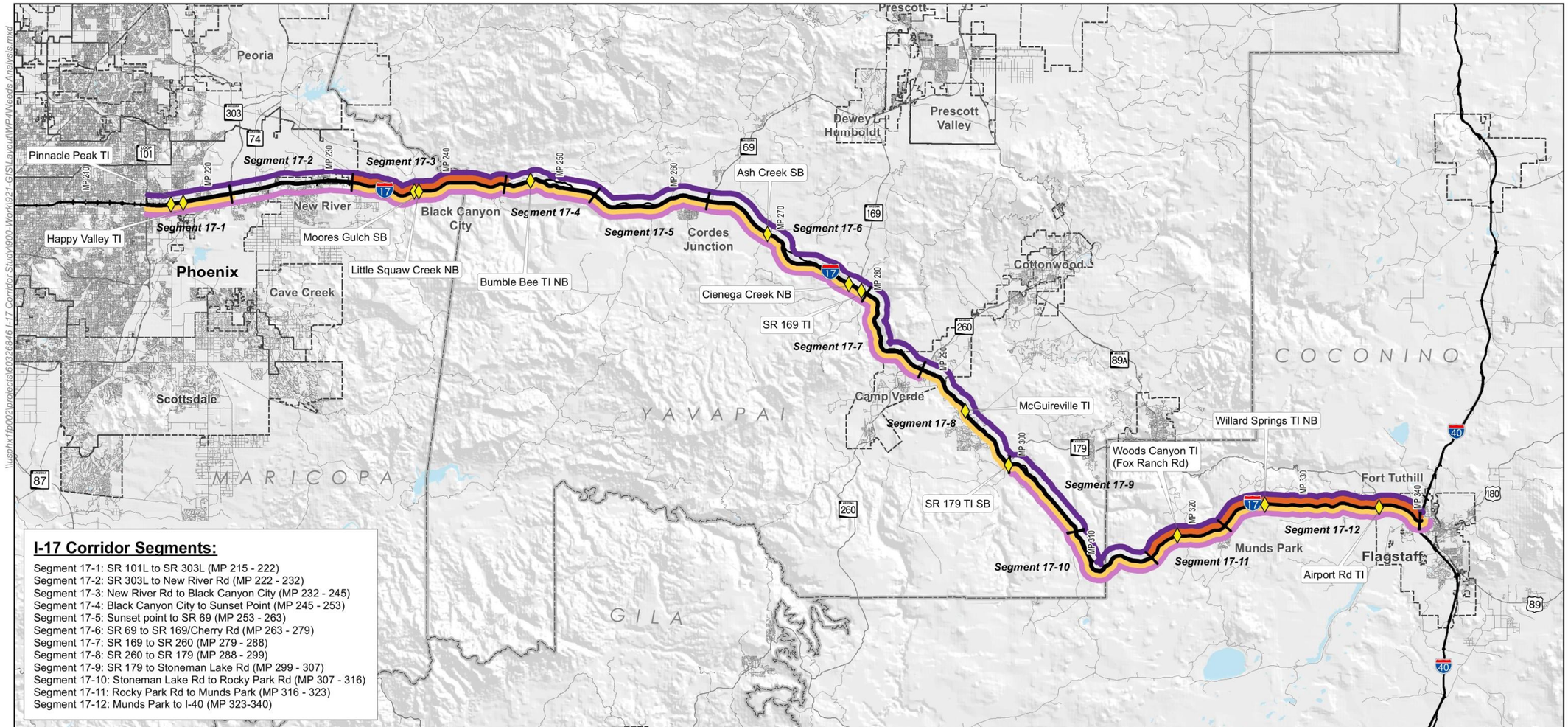
As documented in Working Paper #4, the needs for each segment were combined to numerically estimate the average level of need for each segment of the corridor. During the Corridor Vision process for I-17, the Mobility and Safety Performance Areas were identified as Emphasis Areas. Therefore, during the calculation process a weighting factor of 1.50 was applied to the needs in the Mobility and Safety performance areas. **Figure 3** shows the level of need for each segment by performance area, and the numeric average need for each segment.

Following the distribution of Draft Working Paper #4 (Needs Assessment), several modifications were made to the Performance System (Working Paper #2) and the Needs Assessment process (Working Paper #4) as the overall process has continued to evolve. Therefore, the needs described above and shown in Figures 3 and 4 differ from those shown in Draft Working Paper #4.

2.2 Strategic Investment Areas

The principal objective of the corridor profile study is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State’s key transportation corridors. One of the first steps in the development of strategic solutions was to identify areas of elevated levels of need (medium or high). Addressing areas of medium or high need would have the greatest effect on the corridor performance and should be the focus of the strategic solutions. Segments with Medium or High needs and specific locations of hotspots were considered candidates for strategic solutions. The areas of the I-17 corridor identified for potential strategic investments are shown in **Figure 4.**

Figure 3: Summary of Needs



Segments	17-1	17-2	17-3	17-4	17-5	17-6	17-7	17-8	17-9	17-10	17-11	17-12	Segments
Pavement	None	None	Low	None	None	None	None	None	None	None	Low	Low	Pavement
Bridge	Low	None	Low	Medium	None	Low	None	Low	Low	Low	Low	Medium	Bridge
Mobility*	High	Low	High	High	High	Low	High	None	Low	Low	Low	Low	Mobility*
Safety*	Medium	High	Low	Medium	Low	High	Low	High	High	Low	Medium	Low	Safety*
Freight	Low	None	Low	High	Low	Low	Low	Low	Low	Low	Low	Low	Freight
Average Need (0-3)	1.6	1.0	1.5	2.1	1.2	1.3	1.2	1.1	1.3	0.8	1.3	1.2	Average Need (0-3)

I-17 Corridor Study: MP 215 to 340
Summary of Needs

N

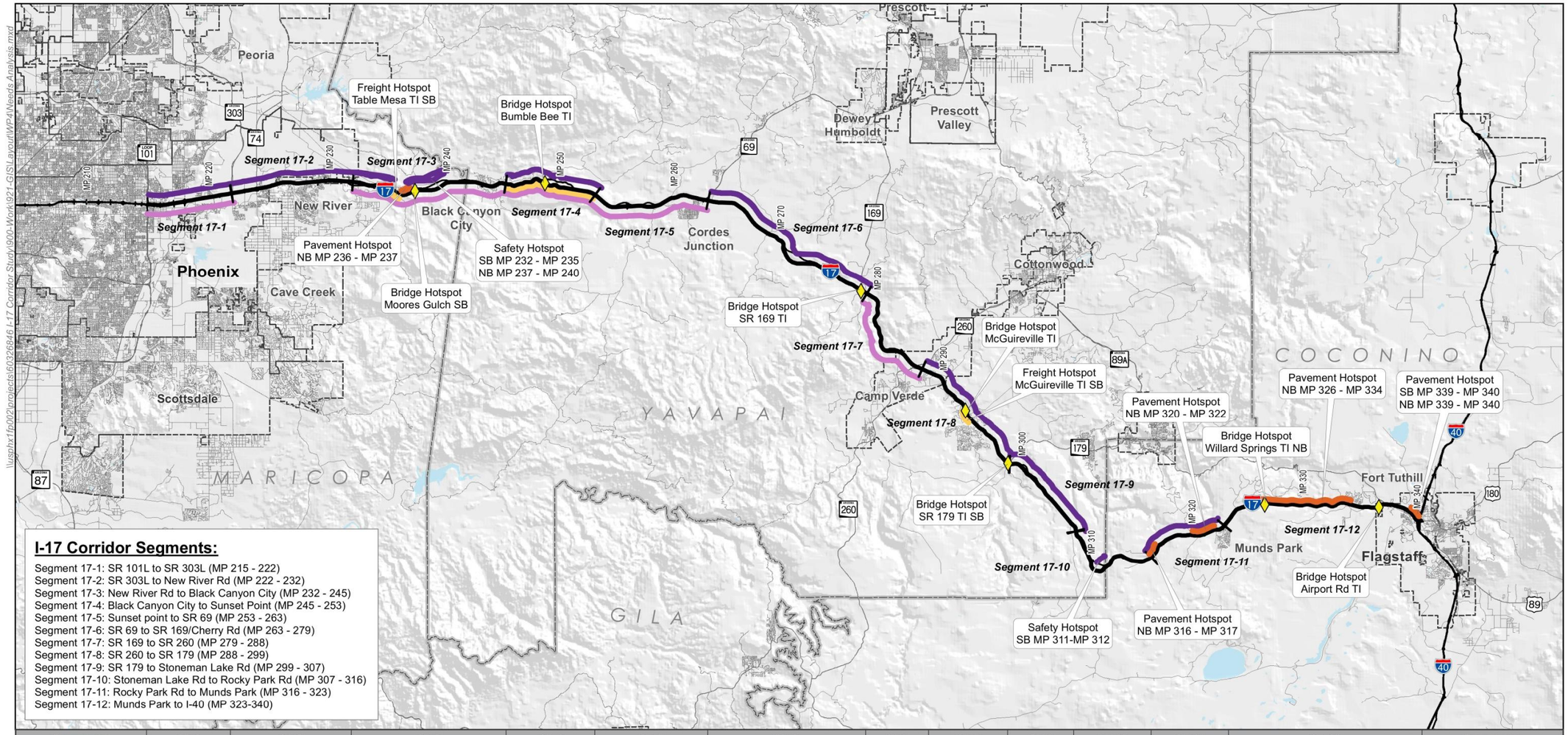
0 2.5 5 10 15 20 Miles

* Identified as Emphasis Area for I-17 corridor

Needs Symbology
- Safety
- Pavement
- Freight
- Mobility
- Bridge

Level of Need
- Low
- Medium
- High

Figure 4: Strategic Investment Areas



I-17 Corridor Segments:

Segment 17-1: SR 101L to SR 303L (MP 215 - 222)
Segment 17-2: SR 303L to New River Rd (MP 222 - 232)
Segment 17-3: New River Rd to Black Canyon City (MP 232 - 245)
Segment 17-4: Black Canyon City to Sunset Point (MP 245 - 253)
Segment 17-5: Sunset point to SR 69 (MP 253 - 263)
Segment 17-6: SR 69 to SR 169/Cherry Rd (MP 263 - 279)
Segment 17-7: SR 169 to SR 260 (MP 279 - 288)
Segment 17-8: SR 260 to SR 179 (MP 288 - 299)
Segment 17-9: SR 179 to Stoneman Lake Rd (MP 299 - 307)
Segment 17-10: Stoneman Lake Rd to Rocky Park Rd (MP 307 - 316)
Segment 17-11: Rocky Park Rd to Munds Park (MP 316 - 323)
Segment 17-12: Munds Park to I-40 (MP 323-340)

Segments	17-1	17-2	17-3	17-4	17-5	17-6	17-7	17-8	17-9	17-10	17-11	17-12	Segments
Pavement	-	-	Hotspot	-	-	-	-	-	-	-	Hotspot	Hotspot	Pavement
Bridge	-	-	Hotspot	Medium	-	Hotspot	-	Hotspot	-	-	-	Medium	Bridge
Mobility*	High	-	High	High	High	-	High	-	-	-	-	-	Mobility*
Safety*	Medium	High	Hotspot	Medium	-	High	-	High	High	Hotspot	Medium	-	Safety*
Freight	-	-	Hotspot	High	-	-	-	Hotspot		-	-	-	Freight
Average Need (0-3)	1.6	1.0	1.5	2.1	1.2	1.3	1.2	1.1	1.3	0.8	1.3	1.2	Average Need (0-3)

* Identified as Emphasis Area for I-17 corridor

I-17 Corridor Study: MP 215 to 340
Strategic Investment Areas

N
0 2.5 5 10 15 20 Miles

Strategic Investment Areas
Safety
Pavement
Freight
Mobility
Bridge

Level of Need
Low
Medium
High

3 STRATEGIC INVESTMENT AREA SCREENING

All of the strategic investment locations (segments and hotspots) were considered for strategic solutions. However, in some cases, needs that have been identified should not be considered for solutions and should be screened from further consideration. Example reasons for screening may include:

- A project has already been programmed to address the need.
- The need has been determined to be 'non-actionable' (cannot be addressed through an ADOT project).
- The conditions/characteristics of the location have changed since the performance data was collected that was used to identify the need.
- Normal programming processes should address typical pavement and bridge needs. Strategic solutions will focus on areas that have existing low performance and that have historical investment concerns. A bridge or pavement need that does not have a historical investment issue will be screened out.
- A Safety Need may not have any discernible trends in the crash data that point to a solution.

Table 2 lists all of the strategic investment areas, identifies which will be advanced for further consideration and which have been screened out, and describes the reason for screening.

Table 2: Strategic Investment Area Screening

Segment	Level of Need					Location #	Need Description	Advance (Y/N)	Screening Description
	Pavement	Bridge	Mobility	Safety	Freight				
17-1 (MP 215 to 222)			High	Medium		L1	Mobility – Projected future travel demand is expected to exceed current capacity	Y	
						L2	Safety – Crash trends show run off road (37%), rear end (23%), and over-turning (37%) crashes	N	Recent reconstruction changed characteristics of segment which would change crash trends that have been identified.
17-2 (MP 222 to 232)				High		L3	Safety – Crash trends show run off road (37%), single vehicle (51%), over-turning (37%), and rear-end (23%) crashes	N	Recent reconstruction changed characteristics of segment which would change crash trends that have been identified.
17-3 (MP 232 to 245)	Hotspot	Hotspot	High	Hotspot	Hotspot	L4	Pavement hotspot – NB MP 236-237 with medium level of previous investment	N	Pavement preservation project programmed in FY 17 and does not meet criteria for previous investment, therefore not considered strategic.
						L5	Bridge hotspot – Moores Gulch SB bridge has current deck and superstructure ratings of 5 with historical concern	N	Bridge replacement programmed in FY 17.
						L6	Mobility – Projected future travel demand is expected to exceed current capacity; high percentage of closure related to incidents/accidents	Y	
						L7	Safety hotspot –NB MP 237-240 and SB MP 232-235	N	No discernible trends in the crash data.
						L8	Freight hotspot – Table Mesa TI bridge has low vertical clearance and cannot be by-passed	Y	
17-4 (MP 245 to 253)		Medium	High	Medium	High	L9	Mobility, Safety, and Freight Needs primarily associated with geometric characteristics of the segment	Y	
						L10	Bridge – Bumble Bee TI bridge has current deck rating of 5 without historical concern	N	Bridge does not meet criteria for historical review, therefore not considered strategic.
17-5 (MP 253 to 263)			High			L11	Mobility – Projected future travel demand is expected to exceed current capacity; needs generally related to grades/terrain	Y	

Segment	Level of Need					Location #	Need Description	Advance (Y/N)	Screening Description
	Pavement	Bridge	Mobility	Safety	Freight				
17-6 (MP 263 to 279)		Hotspot		High		L12	Safety – Crash trends show run off road (72%), single vehicle (94%), over-turning (67%) crashes	Y	
						L13	Bridge hotspot – SR 169 TI bridge has current deck and superstructure ratings of 5 without historical concern	N	Bridge does not meet criteria for historical review, therefore not considered strategic.
17-7 (MP 279 to 288)			High			L14	Mobility – Needs primarily associated with grades in SB direction	Y	
17-8 (MP 288 to 299)		Hotspot		High	Hotspot	L15	Bridge hotspot – SR 179 TI SB bridge has current deck and substructure ratings of 5 without historical concerns	N	Bridge does not meet criteria for historical review, therefore not considered strategic.
						L16	Bridge hotspot – McGuireville TI bridge has current superstructure rating of 4 and has historical concerns	Y	
						L17	Safety – Crash trends show run off road (63%), single vehicle (68%), over-turning (32%) crashes	Y	
						L18	Freight hotspot – McGuireville TI bridge has low vertical clearance and cannot be by-passed	Y	
17-9 (MP 299 to 307)				High		L19	Safety – Crash trends show run off road (62%), single vehicle (81%), fixed object (33%) crashes	Y	
17-10 (MP 307 to 316)				Hotspot		L20	Safety hotspot – SB MP 311-312	Y	
17-11 (MP 316 to 323)	Hotspot			Medium		L21	Pavement hotspot – NB MP 316-317 and 320-322 with low level of previous investment	N	Pavement rehabilitation project is programmed in FY 19 and does not meet criteria for previous investment, therefore not considered strategic.
						L22	Safety – Crash trends show single vehicle (64%), over-turning (50%), dark-unlighted (36%) crashes	Y	
17-12 (MP 323 to 340)	Hotspot	Medium				L23	Pavement hotspot – NB MP 326-334 and 339-340 , SB MP 339-340 with high level of previous investment	Y	Pavement rehabilitation project is programmed in FY 19. Advance to evaluate rehabilitation versus replacement.
						L24	Bridge – Willard Springs TI NB bridge has current deck and superstructure ratings of 5 and historical concerns	N	Bridge replacement programmed in FY 17.
						L25	Bridge – Airport Rd TI bridge has current substructure and superstructure ratings of 5 and historical concerns	Y	

Legend:

	Strategic investment area screened out from further consideration.

4 CANDIDATE CORRIDOR SOLUTIONS

The principal objective of the corridor profile study is to identify strategic solutions (investments) that are performance-based to ensure that available funding resources are used to maximize the performance of the State's key transportation corridors. The corridor profile process is intended to mesh with the Planning to Programming Link (P2P) and will assign strategic solutions to one of the three investment categories: Preservation, Modernization, or Expansion.

The performance needs previously documented in Working Paper #4 (and modified herein) will serve as a foundation for developing strategic solutions for corridor preservation, modernization, and expansion. Strategic investments are not intended to be a substitute or replacement for traditional ADOT project development processes where various candidate projects are developed for consideration in programming in the P2P Link process. Rather, strategic solutions are intended to complement ADOT's traditional project development processes through a performance-based process to address needs in one or more of the five performance areas of Pavement, Bridge, Mobility, Safety, and Freight. Strategic solutions developed for key corridors will be considered along with other candidate projects in the ADOT programming process.

Strategic solutions should have the following characteristics:

- Do not recreate or replace results from normal programming processes
- May include programs or initiatives, areas for further study, and infrastructure projects
- Address elevated levels (high or medium) of need
- Focus on investments in Modernization projects (to optimize current infrastructure)
- Address overlapping needs
- Reduce costly repetitive maintenance
- Extend operational life of system and delay expansion
- Leverage programmed projects that can be expanded to address other strategic elements
- Provide measureable benefit (benefit/cost ratio, risk, LCCA, performance system, etc.)

Establishing uniform solution types will enable the corridor profile process to compare proposed solutions on and across corridors to determine effectiveness at improving performance, including cost and risk comparisons to be undertaken in subsequent tasks. **Appendix A** provides a list of the preliminary solutions currently proposed for the I-17, I-19, and I-40 West corridors which are separated into the three funding categories (Preservation, Modernization, or Expansion).

4.1 Construction Program Solutions

Following the screening process, strategic solutions were developed for each remaining location. The solutions were derived from previous reports, field reviews, ADOT staff input, observable trends in the performance data, current standards, national and local best practices, and engineering judgement. **Table 3** contains the candidate strategic solution for each location. In some cases, multiple candidate solutions are proposed for a single location. These options will be evaluated in subsequent tasks (Task 6) with the intent of identifying one recommended solution for each location. Task 6 will utilize life-cycle cost analyses and benefit cost analyses to evaluate the options. The locations of the candidate solutions are shown in **Figure 5.**

4.2 Other Corridor Solutions

As part of the investigation of strategic investment areas and candidate solutions, other corridor solutions were also identified. These solutions could include modifications to the existing Statewide Construction Program, areas for further study, or other corridor specific recommendations that are construction or policy related. The list below identifies other corridor solutions for the I-17 corridor.

- Conduct study to investigate paving roadway along existing dirt roads connecting Bumble Bee Rd (MP 248) to Bloody Basin Rd (MP 259) for use during closures, similar to N20 interim detour for US 89.
- Continue to provide additional driver messaging and emphasis on safety during holiday weekends.

4.3 Policies and Initiatives

In addition to strategic investment areas, other general corridor and system wide issues were also identified through coordination with project stakeholders. The following list of potential policies and initiatives was derived from the concurrent I-19, I-17, and I-40 West Corridor Profile Studies and was developed for consideration in future project nomination, scoping, and implementation.

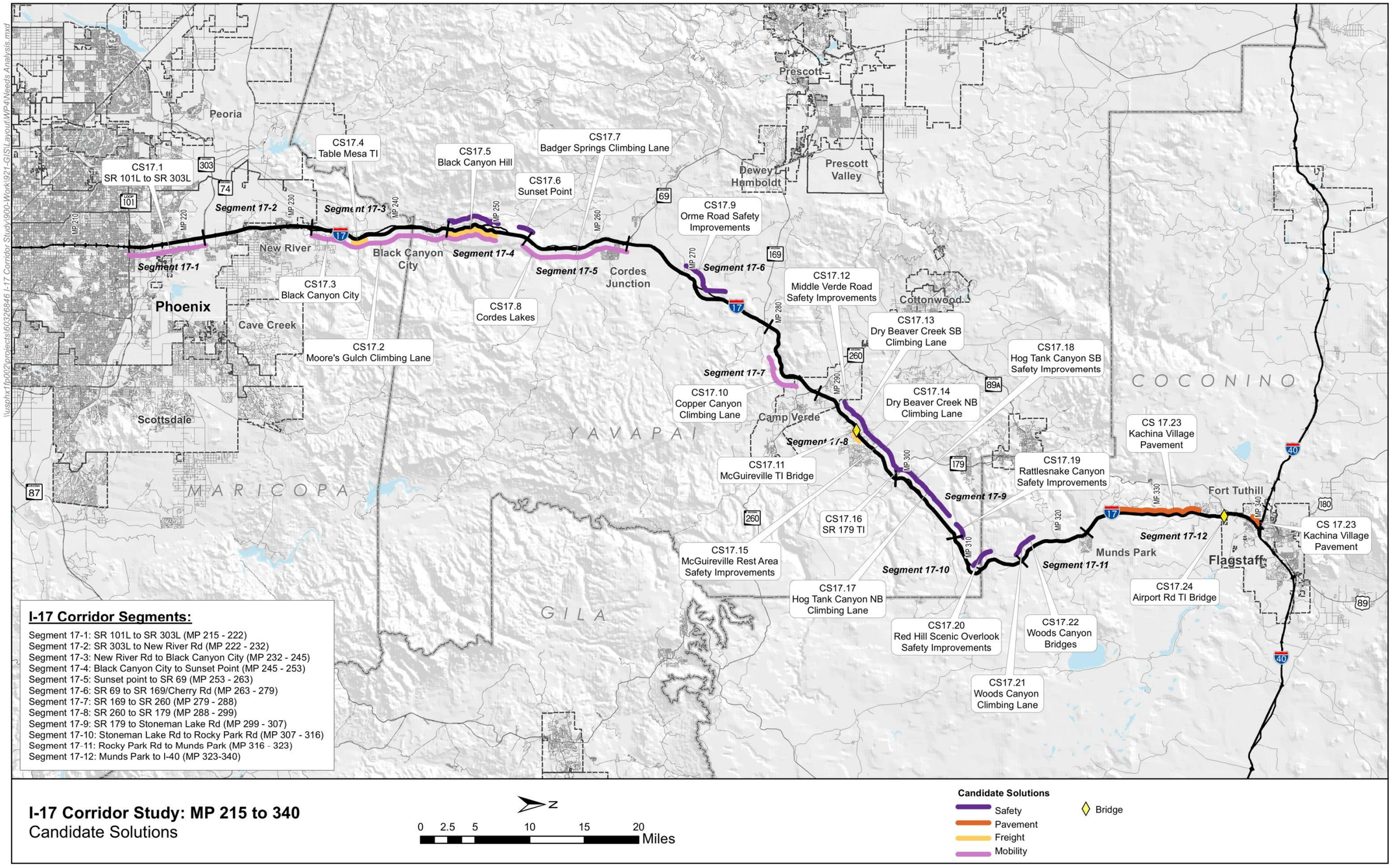
- Install ITS conduit with all new infrastructure projects.
- Prepare strategic plans for Closed Circuit Television (CCTV) and Road Weather Information System (RWIS) locations statewide.
- Leverage power and communication at existing weigh-in-motion (WIM), dynamic messaging signs (DMS), and call box locations to expand ITS applications across the state.
- Consider solar power for lighting and ITS where applicable.
- Investigate ice formation prediction technology where applicable.
- Conduct highway safety manual evaluation for all future programmed projects.
- Develop infrastructure maintenance and preservation plans (including schedule and funding) for all pavement and bridge infrastructure-replacement or expansion projects.
- Develop standardized bridge maintenance procedures so districts can do routine maintenance work.
- Review historical ratings and level of previous investment during scoping of pavement and bridge projects. In pavement locations that warrant further investigation, conduct subsurface investigations during project scoping to determine if full replacement is warranted.
- For pavement rehabilitation projects, enhance the amount/level of geotechnical investigations to address issues specific so the varying conditions along the project.
- Expand programmed and future pavement projects as necessary to include shoulders.
- Expand median cable barrier guidelines to account for safety performance.
- Install CCTV with all DMS.
- In locations with limited communications, use CCTV to provide still images rather than streaming video.
- Develop statewide program for pavement replacement.

Table 3: Candidate Solutions

Solution #	Name	Location #	Milepost	Description	Investment Category (P/M/E)
CS17.1	SR101L to SR 303L	L1	MP 215-222	Option A – Construct general purpose lane Option B - Variable speed limits	E M
CS17.2	Moore's Gulch Climbing Lane	L6	MP 237-239 (SB)	Construct southbound climbing lane	M
CS17.3	Black Canyon City	L6	MP 229-245	Option A – Construct general purpose lane Option B – Variable speed limits	E M
CS17.4	Table Mesa Rd TI	L8	MP 236	Option A – Reprofile southbound roadway Option B – Construct new southbound exit ramp	M
CS17.5	Black Canyon Hill	L9	MP 245-251	Option A – Construct northbound climbing lane Option B – Construct reversible lane(s) Option C – Shoulder running for northbound traffic Option D – Variable speed limits for both directions Enhance roadside design (replace guardrail with concrete barrier) Enhance delineation (pavement marking, delineators, rumble strips) Install curve warning signs and chevrons Excavate/grade cut slopes to improve sight distance Install dynamic speed feedback system on southbound roadway near MP 248 and 251	M
CS17.6	Sunset Point	L9	MP 252-253	Construct/extend parallel entrance and exit ramps at Sunset Point TI Install roadway weather information system (RWIS) Install dynamic wind warning system	M
CS17.7	Badger Springs Climbing Lane	L11	MP 256-260 (NB)	Construct northbound climbing lane	M
CS17.8	Cordes Lakes	L11	MP 253-263	Enhance existing crossovers for use to reroute traffic during closures	M
CS17.9	Orme Road Safety Improvements	L12	MP 269-274 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system	M
CS17.10	Copper Canyon Climbing Lane	L14	MP 282-286 (SB)	Construct southbound climbing lane	M
CS17.11	McGuireville TI Bridge	L16 & L18	MP 293	Option A – Rehabilitate McGuireville TI bridge and construct new southbound exit ramp Option B – Replace McGuireville TI bridge	P M
CS17.12	Middle Verde Road Safety Improvements	L17	MP 290-292 (NB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install CCTV on existing DMS located at MP 289	M
CS17.13	Dry Beaver Creek Southbound Climbing Lane	L17	MP 292-294 (SB)	Construct southbound climbing lane	M
CS17.14	Dry Beaver Creek Northbound Climbing Lane	L17	MP 294-298 (NB)	Construct northbound climbing lane	M

Solution #	Name	Location #	Milepost	Description	Investment Category (P/M/E)
CS17.15	McGuireville Rest Area Safety Improvements	L17	MP 295-298 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install CCTV on existing DMS located at MP 297.4	M
CS17.16	SR179 TI	L17	MP 299	Construct/extend parallel entrance and exit ramps at SR179 TI Install solar powered LED lighting at ramp gores	M
CS17.17	Hog Tank Canyon Northbound Climbing Lane	L19	MP 299-305 (NB)	Construct northbound climbing lane Install new DMS at MP 303.4 with CCTV	M
CS17.18	Hog Tank Canyon Southbound Safety Improvements	L19	MP 300-302 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Install solar-powered LED lighting Excavate/grade cut slopes to improve sight distance	M
CS17.19	Rattlesnake Canyon Safety Improvements	L19	MP 306-307 (NB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install dynamic speed feedback system Construct/extend northbound parallel entrance ramp at Stoneman Lake TI Install CCTV near MP 306.5	M
CS17.20	Red Hill Scenic Overlook Safety Improvements	L20	MP 311-313 (SB)	Increase skid resistance (reconstruct pavement, increase super-elevation, or mill and replace) Enhance delineation (striping, delineators, rumble strips) Install curve warning signs and chevrons Install solar powered LED lighting at ramp gores Install dynamic speed feedback system Install CCTV near MP 312.3 Construct/extend southbound parallel exit and entrance ramp at scenic overlook	M
CS17.21	Woods Canyon Climbing Lane	L22	MP 316-317 (SB)	Construct southbound climbing lane	M
CS17.22	Woods Canyon Bridges	L22	MP 317	Option A – Replace Woods Canyon bridge decks, increase skid resistance, and install de-icing system Option B – Realign roadway and construct new bridges over Woods Canyon with de-icing system Enhance delineation (striping, delineators, rumble strips) Excavate/grade cut slopes and remove trees to reduce roadway shading Install roadway weather information system (RWIS) near Rocky Park TI or Woods Canyon	M
CS17.23	Kachina Village Pavement	L23	MP 326-334 (NB) MP 339-340 (NB) MP 339-340 (SB)	Option A – Rehabilitate pavement Option B – Replace pavement	P M
CS17.24	Airport Rd TI Bridge	L25	MP 337	Option A – Rehabilitate Airport Rd TI bridge Option B – Replace Airport Rd TI bridge	P M

Figure 5: Candidate Solutions



5 NEXT STEPS

Candidate Solutions identified in Working Paper #5 will be advanced to an evaluation process including a Life Cycle Cost or Benefit Cost Analysis (where applicable), Risk Analysis, and a Performance Effectiveness Analysis. The methodology and approach to this analysis is briefly described below and will be documented in detail in Working Paper #6. **Figure 6** illustrates the candidate solution evaluation process.

Life Cycle Cost Analysis – All pavement and bridge candidate solutions have two options, rehabilitation or reconstruction. These options will be evaluated through a life cycle cost analysis to determine the most effective approach for each location where a pavement or bridge solution is recommended. The recommended option will be advanced to the Performance Effectiveness and Risk Analysis evaluations.

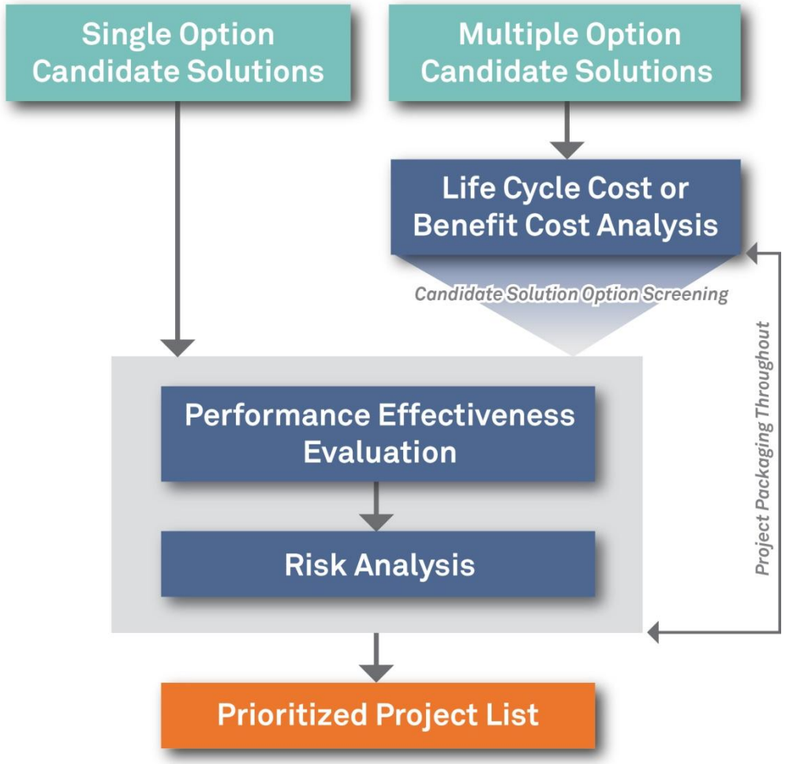
Benefit Cost Analysis –Strategic areas that resulted in multiple independent candidate solutions will be evaluated through a benefit cost analysis to determine the most effective solution. The recommended option will be advanced to the Performance Effectiveness and Risk Analysis evaluations.

Performance Effectiveness Evaluation – After the LCCA and BCA processes are complete, all remaining candidate solutions will be evaluated based on their performance effectiveness. This process will include determining a performance effectiveness score based on how each solution increases existing performance scores (Working Paper #2) and how much the segment level need (Working Paper #4) is decreased. The results of this evaluation will be combined with the results of the Risk Analysis to determine which solutions have the highest priority in the corridor.

Risk Analysis – All candidate solutions that are advanced through the Performance Effectiveness evaluation will also be evaluated through a Risk Analysis process. This process will examine the risk of not implementing a recommended solution in terms of overall corridor performance. The results of this analysis will be combined with the Performance Effectiveness scores to determine the highest priority solutions in the corridor.

The highest ranking solutions will become recommended strategic investments for consideration in the Planning to Programming Link (P2P) process along with other nominated projects.

Figure 6: Candidate Solution Evaluation Process



APPENDIX A:

Solution Types

PRESERVATION

REHABILITATION

- Rehabilitate Pavement
- Rehabilitate Bridge

MODERNIZATION

GEOMETRIC IMPROVEMENT

- Re-profile Roadway
- Realign Roadway
- Improve Skid Resistance

INFRASTRUCTURE IMPROVEMENT

- Construct Auxiliary Lanes
- Construct Climbing Lane
- Construct Reversible Lane
- Construct Entry/Exit Ramp
- Modify Entry/Exit Ramp
- Replace Pavement
- Replace Bridge
- Implement Automated Bridge De-icing

OPERATIONAL IMPROVEMENT

- Implement Variable Speed Limits
- Implement Ramp Metering
- Implement Shoulder Running

ROADSIDE DESIGN

- Install Guardrail
- Widen Shoulder
- Rehabilitate Shoulder
- Replace Shoulder
- Install Rumble Strip
- Install Safety Edge
- Remove Tree/Vegetation

MODERNIZATION (CONTINUED)

ROADWAY DELINEATION

- Install High-Visibility Edge Line Striping
- Install High-Visibility Delineators
- Install Raised Pavement Markers

IMPROVED VISIBILITY

- Cut Side Slopes
- Install Lighting

DRIVER INFORMATION/WARNING

- Install Dynamic Message Sign (DMS)
- Install Dynamic Weather Warning Beacons
- Install Speed Feedback Signs
- Install Chevrons
- Install Warning Signs

DATA COLLECTION

- Install Roadside Weather Information System (RWIS)
- Install Closed Circuit Television (CCTV) Camera
- Install Vehicle Detection Stations

EXPANSION

WIDEN CORRIDOR

- Construct New General Purpose Lane

ALTERNATE ROUTE

- Construct Frontage Roads